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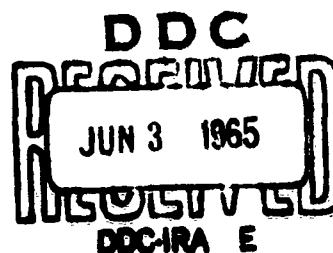
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7. TIME DEPENDENCE OF THE RADIO EMISSION  
FROM CTA 21 AND CTA 102

by

P. Maltby and A. T. Moffet

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Observations

of the

# OWENS VALLEY RADIO OBSERVATORY

California Institute of Technology  
Pasadena, California

1965

TIME DEPENDENCE OF THE RADIO EMISSION  
FROM CTA 21 AND CTA 102

by

P. Maltby\* and A. T. Moffet

Sholomitskii (1965) has recently presented evidence for changes in the radio emission from the source CTA 102. Sholomitskii finds that his observed intensities at a wavelength of 32.5 cm may be fitted to a sinusoidal law with a period of about 100 days and an amplitude of  $\pm$  23%. His result is based on a comparison of the flux densities of CTA 21 and CTA 102 with that of 3C 48, apparently on nine days within the period August, 1964, to February, 1965.

Since their discovery in 1959 (Harris and Roberts 1960), the radio sources CTA 21 and CTA 102 have been studied fairly extensively at this observatory. In particular, we carried out two series of brightness distribution measurements (Moffet 1962; Maltby 1962) during 1960 and early 1961 at a wavelength of 31.3 cm, very close to that used by Sholomitskii. An additional group of observations at this wavelength were made in September, 1961, by Kellermann (1964). In this paper we will restrict our discussion to these 31.3-cm observations. We will show that in 1960 no intensity variation was present having the amplitude and period reported by Sholomitskii.

The 31.3-cm observations of CTA 21 and CTA 102 are summarized in Table 1. The 1959 observations were made with a Dicke radiometer on one 90-ft antenna. All subsequent observations were made with two 90-ft antennas connected as an interferometer. The interferometer has been described in detail by Read (1961, 1963). Recent high-resolution interferometric studies (Anderson, Donaldson, Palmer, and Rowson 1965) have shown that both CTA 21 and CTA 102 have angular diameters of less than 0.4". This means these sources are not at all resolved by any interferometer spacing used in the Caltech observations; thus each of our observations gives a measure of the total flux from these sources.

In order to look for possible variations in the intensity of a particular radio source, it is necessary to correct for variations in receiver gain and other instrumental factors. The calibration procedures for the Caltech observations have been discussed in the papers cited above. In general, a number of small-diameter sources are used as standards for each day's observations.

The fluxes in Table 1 are on Kellermann's intensity scale, which is about 3.5% lower than that used by Harris and Roberts and by Moffet and Maltby. Fig. 1 shows the fluxes plotted versus time. For comparison we have included in Fig. 1 Sholomitskii's measurements in 1964 and

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1965, which are copied from the figure accompanying his note. These have been converted to fluxes by assuming an intensity of  $21.0 \times 10^{-26}$   $\text{W m}^{-2}(\text{c/s})^{-1}$  for 3C 48. The dashed curve is the sinusoidal intensity variation suggested by Sholomitskii for CTA 102.

Most of the points for our observations represent averages over several days, as is indicated in Table 1. Except for the single-dish observations of 1959, the greatest span of time represented by a single point is 13 days. If the individual observations were plotted, the scatter would be about the same as the scatter among the points representing the averages at different interferometer spacings.

As is seen in Fig. 1, our observations show the flux density of CTA 102 to be constant to within  $\pm 4\%$  of the mean, while the observations of CTA 21 are constant to within  $\pm 8\%$ . The difference between these two figures is not significant, and we conclude that no variation with an amplitude as great as  $\pm 10\%$  was present during the periods of our observations. The two series of observations at the beginning and end of 1960 cover spans of 60 to 90 days. They would have been quite sensitive to variations with a period of about 100 days, as reported by Sholomitskii. However, the four different series of Caltech observations happened to come at intervals of about 8 months. Thus we would be less sensitive to intensity fluctuations with periods of about 240 or 480 days. It might also be argued that variations in the intensity of CTA 102 commenced after 1961, although this seems to us rather unlikely.

It is difficult to account for the discrepancy between Sholomitskii's and our observations. Sholomitskii states that the variations he observed were "far in excess of the errors of measurement." In an earlier paper Sholomitskii, Kuril'chik, Matveenko and Khromov (1964) report measurements of other radio sources at 32 cm, presumably made with the same instrument. Flux errors for measurements reported in that paper range from  $\pm 0.25$  to  $\pm 1.0$  flux units. The maximum range in flux reported by Sholomitskii for CTA 102 is 2.3 flux units. Thus the range of variation is not much larger than the greatest errors quoted by Sholomitskii et al. Sholomitskii et al report some of the details of their radiometer, but the characteristics of the antenna they used have not yet appeared in the literature. Until the characteristics of this antenna are published, it is difficult to evaluate any observations made with it. To cite one specific example, it is impossible to judge the effect of solar radiation entering the antenna sidelobes when no information has been published about the reception pattern of the antenna.

Sandage and Wyndham (1965) have identified CTA 102 with a quasi-stellar object. If CTA 102 has a radio luminosity equal to that of other objects in this class, it is possible to calculate a minimum diameter for the source region. The observed radio spectrum requires that the source be optically thin for frequencies above  $10^3$  Mc/s. Cutoff frequencies for synchrotron self-absorption, free-free absorption and the Tsytovich effect (see Scheuer 1965 for a review of these mechanisms) must be less than this value. If we assume that the density of thermal electrons is  $\leq 10^2 \text{ cm}^{-3}$  and the magnetic field is in the range  $10^{-2}$  to  $10^{-4}$  oersted, then the minimum size is about 100 pc.

Sholomitskii has pointed out that an intensity variation with a period of 100 days requires a source diameter of 0.1 pc or less. A detailed consideration of the problem of variation in radio sources is beyond the scope of this paper. If the radio emission from quasi-stellar objects does show short-period variations, our present concept of these objects must be revised; in particular, their large redshifts must then be of other than cosmological origin.

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Table 1  
FLUX DENSITIES OF CTA 21 and CTA 102 AT 31.3 CM

Date	Spacing	CTA 21		CTA 102		No. of Observations
		Flux Density [ $10^{-26} \text{Wm}^{-2} (\text{c/s})^{-1}$ ]	No. of Observations	Flux Density [ $10^{-26} \text{Wm}^{-2} (\text{c/s})^{-1}$ ]	No. of Observations	
1959 Aug-Nov	0	8.7 ± 1.0	4	7.0 ± 0.6	3	
1960 Feb 25-29	195λ EW	8.1 ± 0.9	2	...	...	
March 3-4	126λ EW	8.1 ± 1.1	1	...	1	
April 5-8	292λ EW	8.4 ± 1.1	1	7.1 ± 0.8	1	
April 29-30	779λ EW	...	...	7.5 ± 0.9	1	
May 14-19	1557λ EW	...	...	7.5 ± 0.8	4	
May 21-22	1168λ EW	8.3 ± 1.1	1	...	...	
May 27-28	973λ EW	8.6 ± 1.2	1	...	...	
1960 Nov 29-Dec 12	172λ NS	...	...	7.6 ± 0.3	5	
Dec 3-6	178λ NS	9.5 ± 0.6	3	...	...	
1961 Jan 3-9	356λ NS	9.0 ± 0.3	4	...	...	
Jan 5-15	344λ NS	...	...	7.3 ± 0.3	3	
Jan 19-22	688λ NS	...	...	7.4 ± 0.4	3	
Jan 20-24	712λ NS	8.7 ± 0.3	3	...	...	
Feb 10-12	1424λ NS	8.9 ± 0.4	2	...	...	
Feb 10-12	1376λ NS	...	...	7.0 ± 0.4	2	
1961 Aug 30-Sep 4	98λ EW	9.2 ± 0.3	2	7.2 ± 0.3	3	

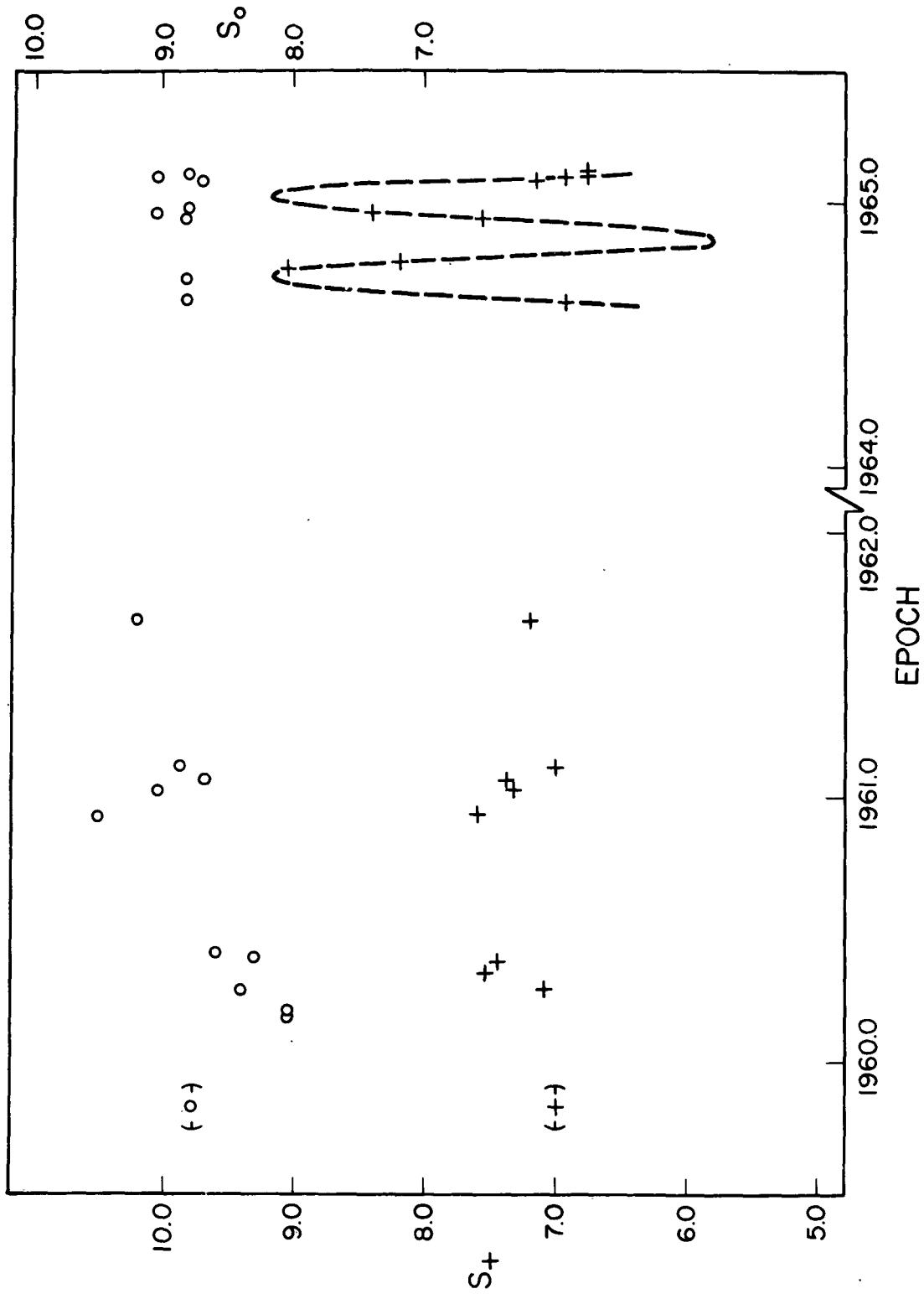


Figure 1. Measured intensities of CTA 102 (crosses and intensity scale on left) and of CTA 21 (circles and scale on right). For comparison we have plotted on the right the data and suggested light curve of Sholomitskii (1965). Units are  $10^{-26} \text{ W m}^{-2} (\text{c/s})^{-1}$ .

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13. ABSTRACT  <p>Sholomitskii has reported variations with a period of about 100 days and amplitude of <math>\pm</math> 23% in the 32.5 cm radio intensity of CTA 102. We have examined the Caltech observations of this source at 31.3 cm, which cover the period from its discovery in 1959 through 1961. A firm upper limit of <math>\pm</math> 10% can be set on variations with 100 day period.</p>		